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Appendix E

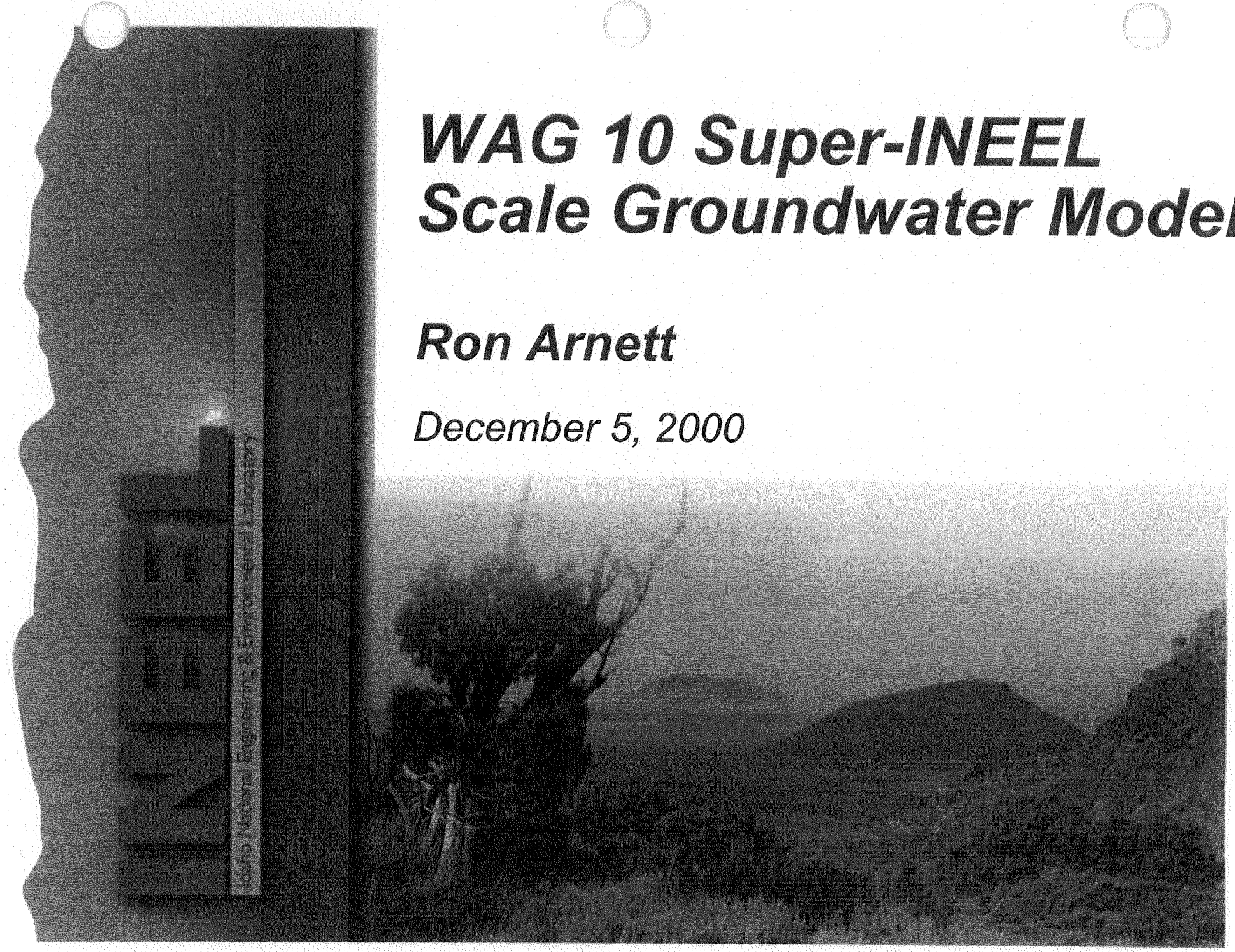
WAG 10 OU 10-08 Groundwater Model

Section E-1. WAG 10 OU 10-08 Super-INEEL Scale Groundwater Model Presentation.

WAG 10 Super-INEEL Scale Groundwater Model

Ron Arnett

December 5, 2000



WAG 10 SUPER-INEEL SCALE GROUNDWATER MODEL

Objectives

- Provide a reasonable and consistent INEEL scale advective groundwater velocity field that supports, takes into account important features, and integrates the results of facility specific WAG contaminant transport models

- Evaluate INEEL scale cumulative risk of intermingling plumes from various WAGS

- Identify data gaps and support design of INEEL groundwater monitoring network.

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Purposes of Numerical Models

- Integration of data and concepts
- Test hypotheses
- Guide collection of data

Purposes of This Presentation

- Describe our current guiding concepts
- Show the application of our modeling to the evaluation of our concepts

WAG 10 SUPER-INEEL SCALE GROUNDWATER MODEL

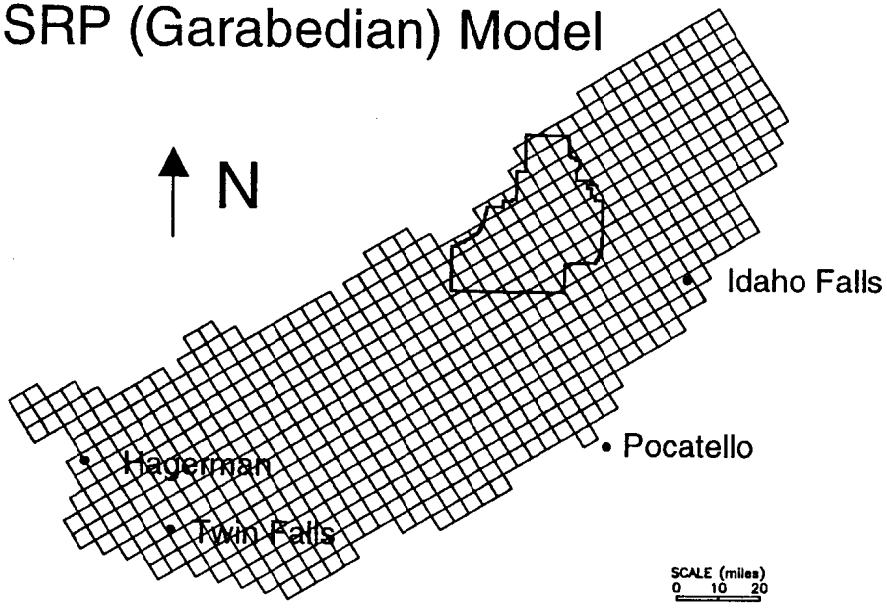
Approach

- Use info and lessons learned from previous models
- Update the Conceptual Model
- Account for relevant info and results of facility scale models and analyses
- Consider uncertainty and possible probabilistic approaches

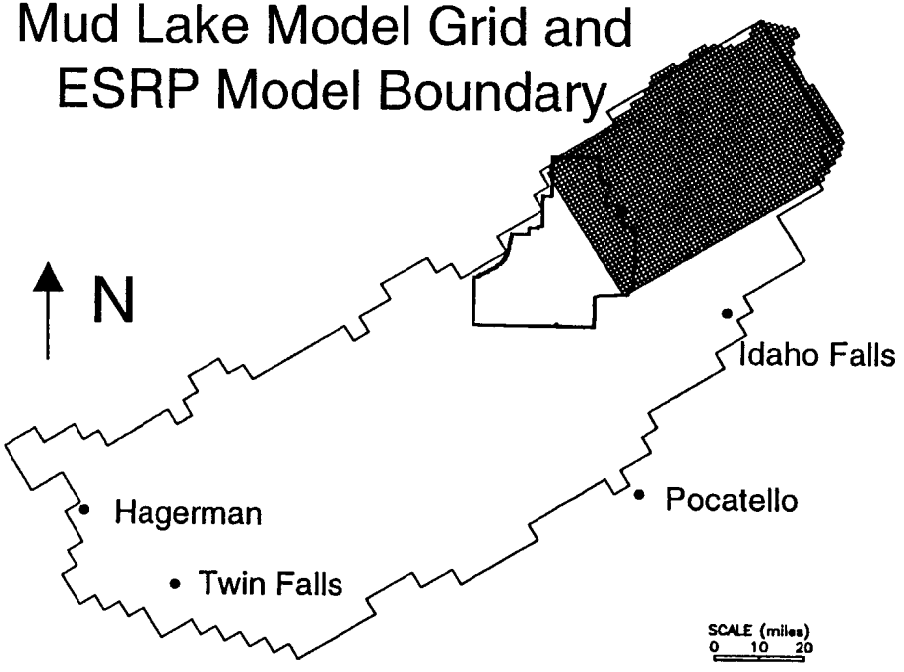
Selected Previous Groundwater Models

- USGS Eastern Snake River Plain (Garabedian, 1989)
- USGS Mud Lake Area Model (Spinazola, 1994)
- INEEL EIS Flow and Transport Model (Arnett, et al,1993)
- Preliminary WAG 10 Flow Model (McCarthy et al, 1995)
- WAG 1,3,7 Models

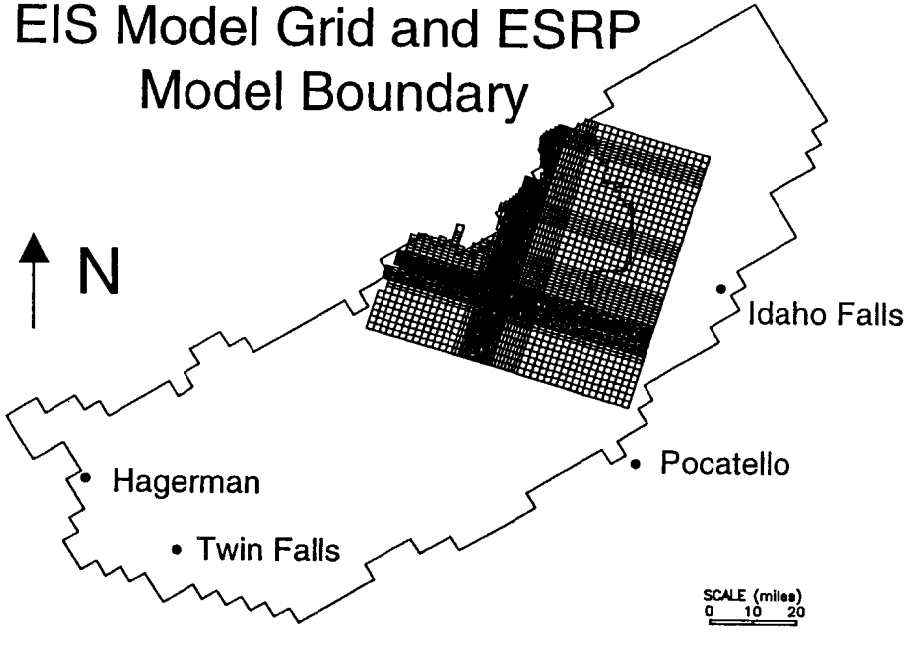
ESRP (Garabedian) Model



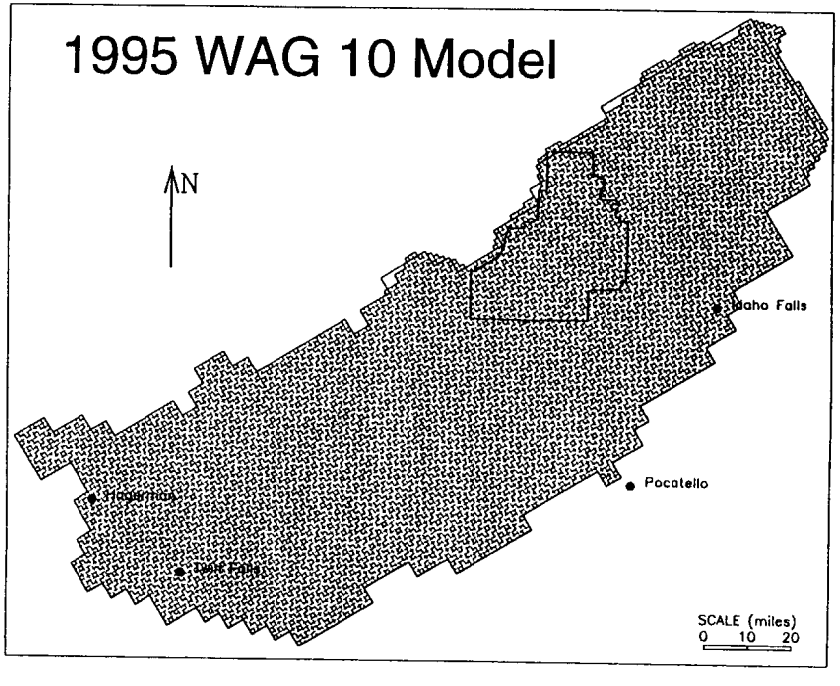
Mud Lake Model Grid and ESRP Model Boundary



EIS Model Grid and ESRP Model Boundary



1995 WAG 10 Model

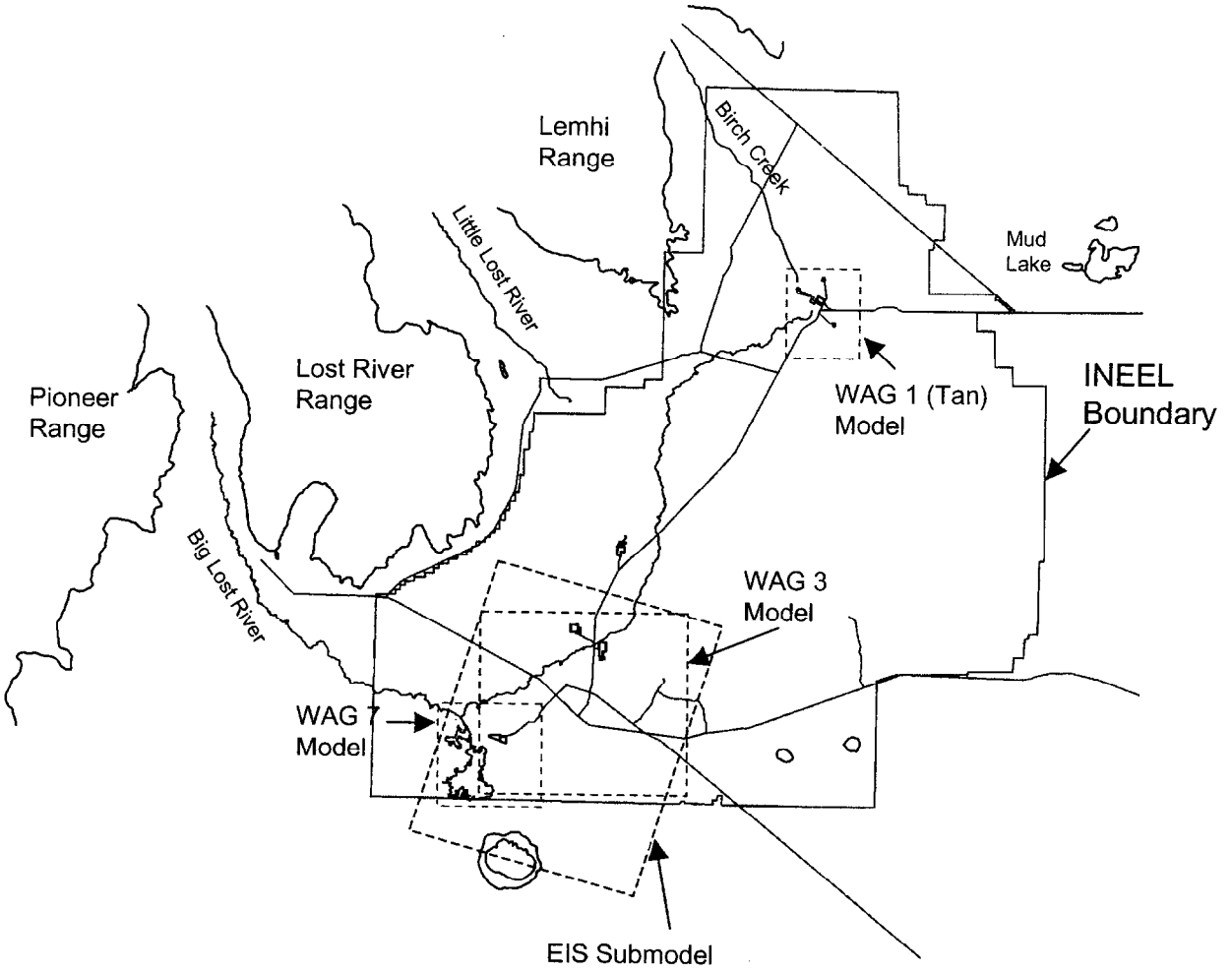


Value & Limits of 1995 Wag 10 Model

- Integrated WAG 10 (INEEL) scale with regional scale
- Increased the resolution of regional scale model
- Incorporated Mud Lake Model

- Head and velocity field resolution was inadequate for facility specific WAG needs
- Didn't include some recent data (wells, aquifer thickness, etc.)
- Didn't include some features important to facility specific WAG modeling efforts.

Facility Specific WAG and EIS Model Domains



WAG 1 (TAN) Model

- Newest TAN model used updated geology and hydraulic gradient
- Eastward dog leg in TCE plume could be generated from a low permeability zone south-west of TSF (generated from pump test results) and updated gradient influenced by production wells and ponds
- Using QR interbed as contaminated aquifer base needed a porosity of 0.03 to match observed TCE and Tritium
- 15 layers

Newest WAG 3 (INTEC) Model

- Matching local WAG3 area heads provided better agreement with chemistry inferred flow paths than 1994 WAG 10 model
- Using updated aquifer thickness from temperature logs required effective porosity of 0.03 to match tritium
- Updated layering resolution particularly for the HI interbed - 18 aquifer layers
- Simulated tritium concentrations downgradient of INTEC (CFA and beyond) are nearly as high in the deep aquifer (>200-300 m aquifer depth) as in the shallow aquifer (< 100 meters)

WAG 7 (RWMC) Model

- Low-permeability area towards S-SW appears to strongly influence local gradients and may facilitate flow reversals in response to spreading area discharges.

- Improved well coverage since 1995 will help interpretation of local gradients.

- Ambient gradient tracer test in M17S (inside the SDA) will improve understanding of local gradients and what conditions affect them.

- Zone of elevated concentrations in aquifer from SDA contaminants has consistently been to the north-northeast. In the last two years, elevated CCl_4 concentrations have also been detected in USGS 120, next to Spreading Area B.

- 8 aquifer layers (additional vadose zone layers)

Conceptual Model

- Model domain *
- Model boundary conditions *
- Recharge/discharge
- Aquifer thicknesses and model layering *
- Flow directions and velocity *
  - aquifer thickness and anisotropy of geologic framework
  - chemistry indicators
- Hydraulic property distributions
- Temporal variations
- Locations of contaminant sources

Model Domain

- Horizontal extent similar to EIS model or proposed USGS Model
- Northeast and southwest boundaries at arbitrary locations sufficiently distant from INEEL
- Western boundary along mountain ranges or tributary basin mouths
- Eastern boundary along regional flow line
- 3-5 variable thickness layers

Water Budget

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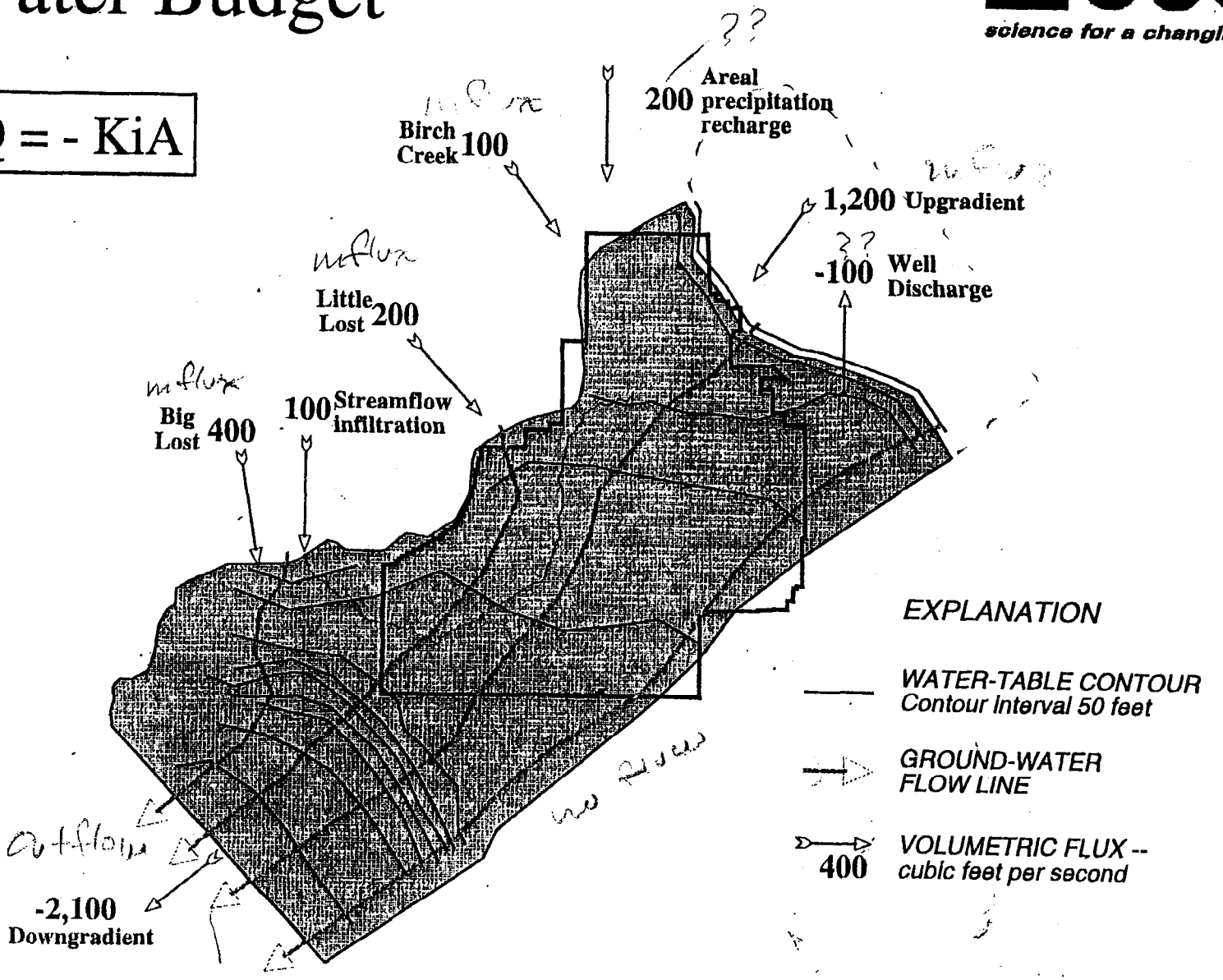
$$Q = -KiA$$

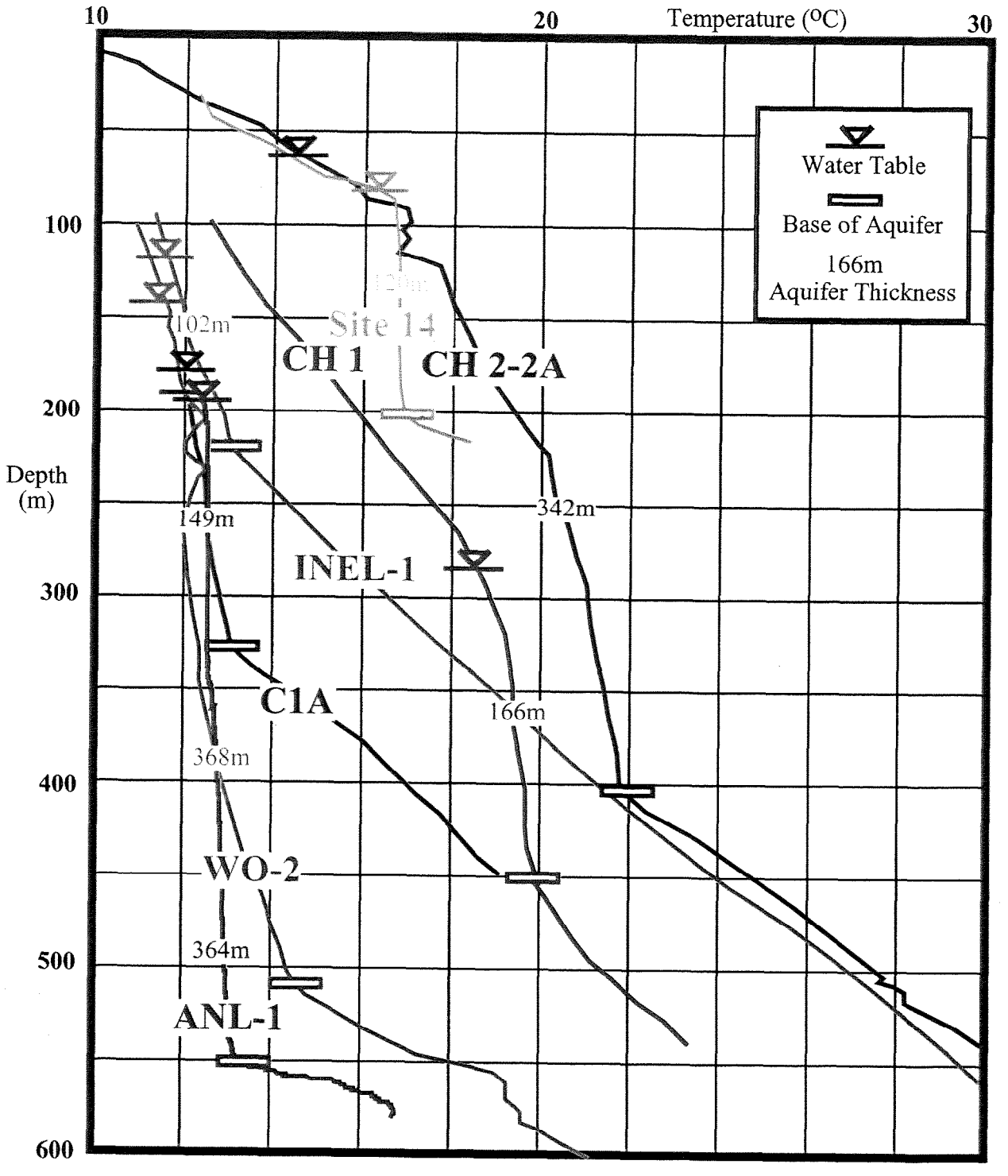


Model Boundary Conditions

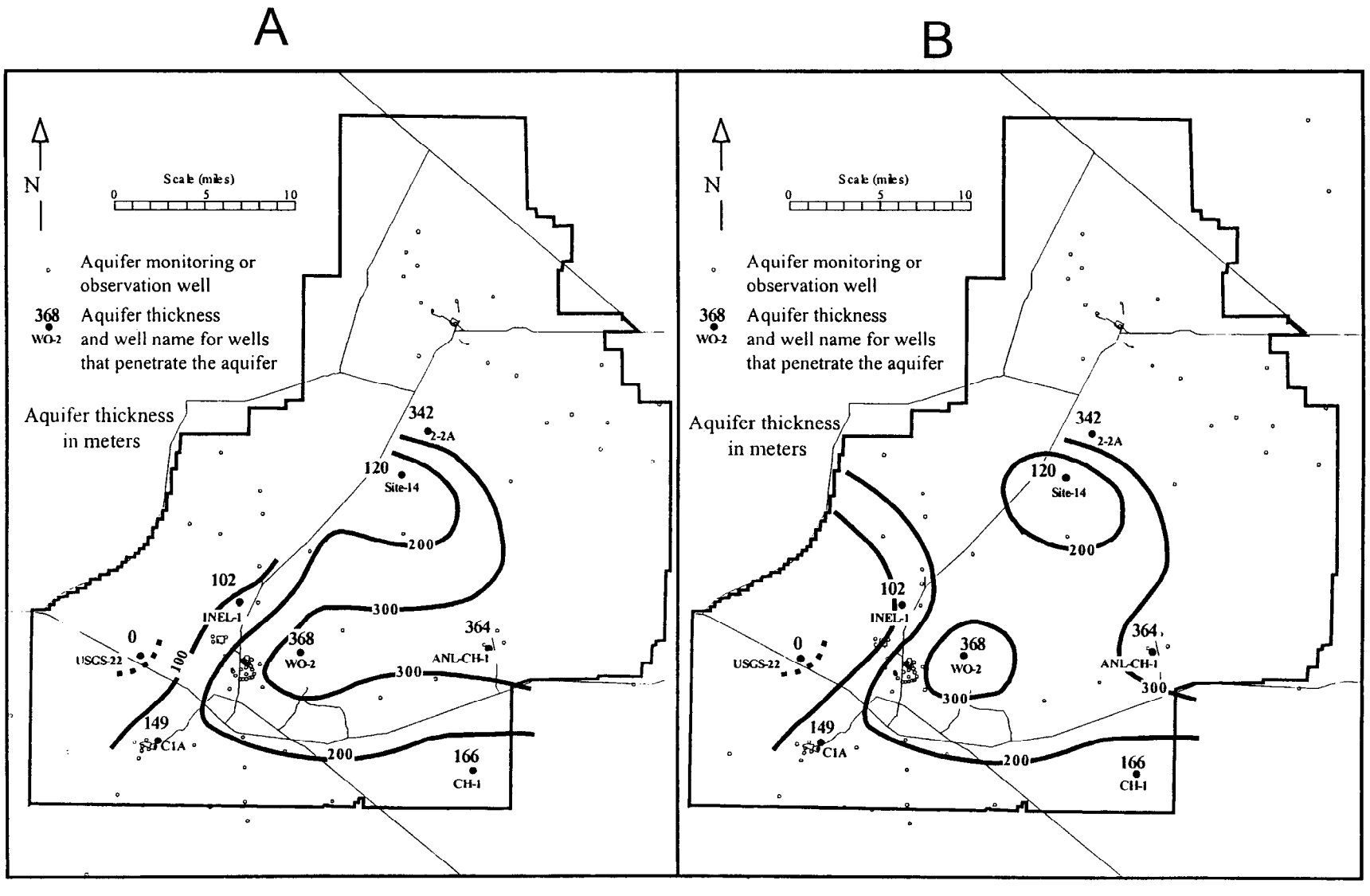
- Model input boundary conditions must be estimated independently of the model (model input)
- GW underflow from tributary basins to be estimated independently
- No flux across eastern boundary (region flow line)
- Northeastern influx from 1995 WAG10 model
- Southeastern output boundary flux to be calculated by model

Aquifer Thickness and Model Layering

- Aquifer thickness is variable across the site
- Upper portion has previously been considered to carry most of the contaminants (may not be true, observed vertical profiles of contaminant concentrations not available).
- Need 1-2 model layers in this portion
- Recent evidence that the aquifer thins dramatically near the southwestern boundary of the INEEL
- 2-3 layers to simulate the deeper portions of the aquifer



Temperature logs of wells and exploration drill holes that penetrate the base of the aquifer.



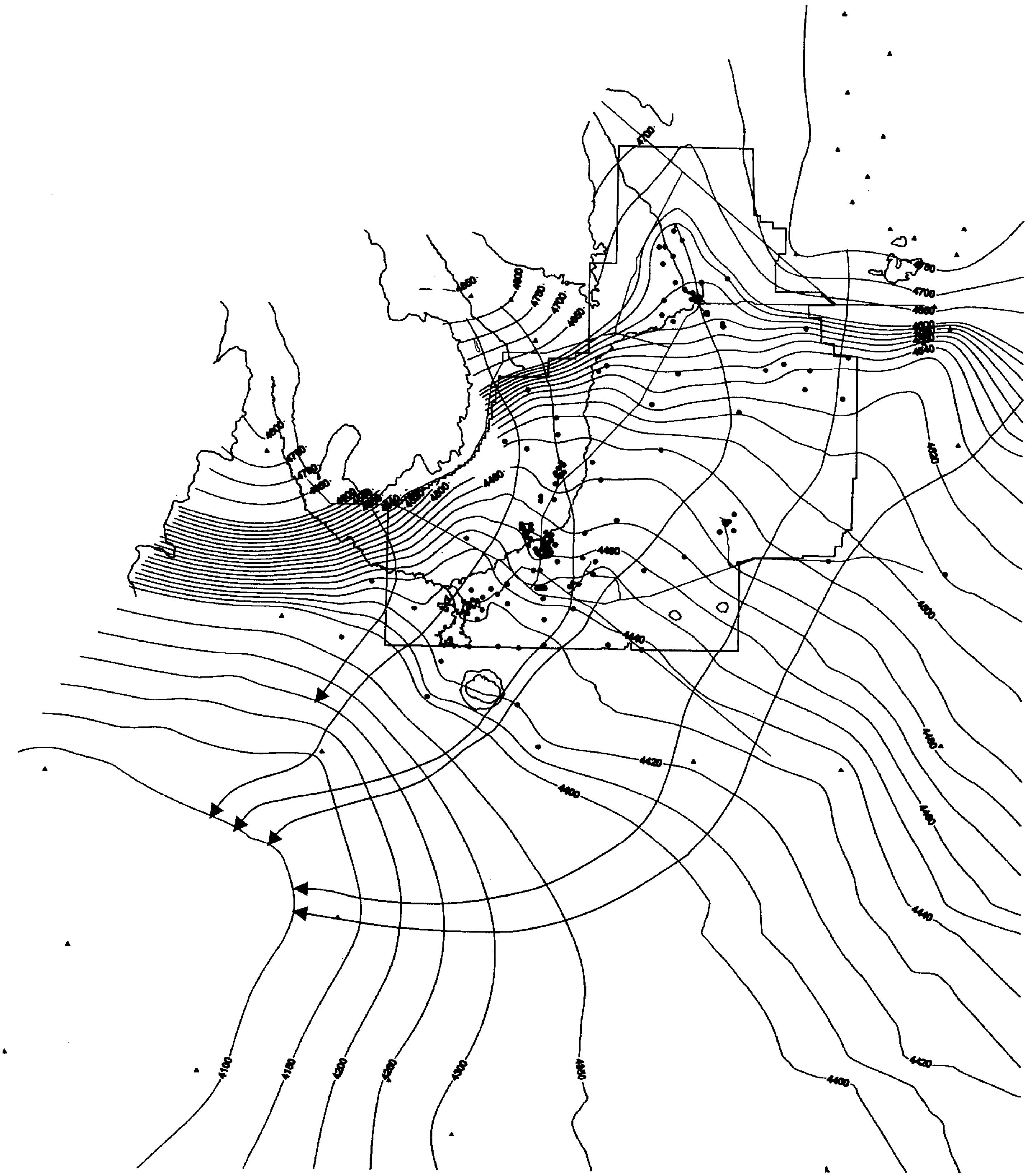
Two interpretations of contours of aquifer thickness based on temperature logs of wells which penetrate the aquifer

Groundwater Flow Directions

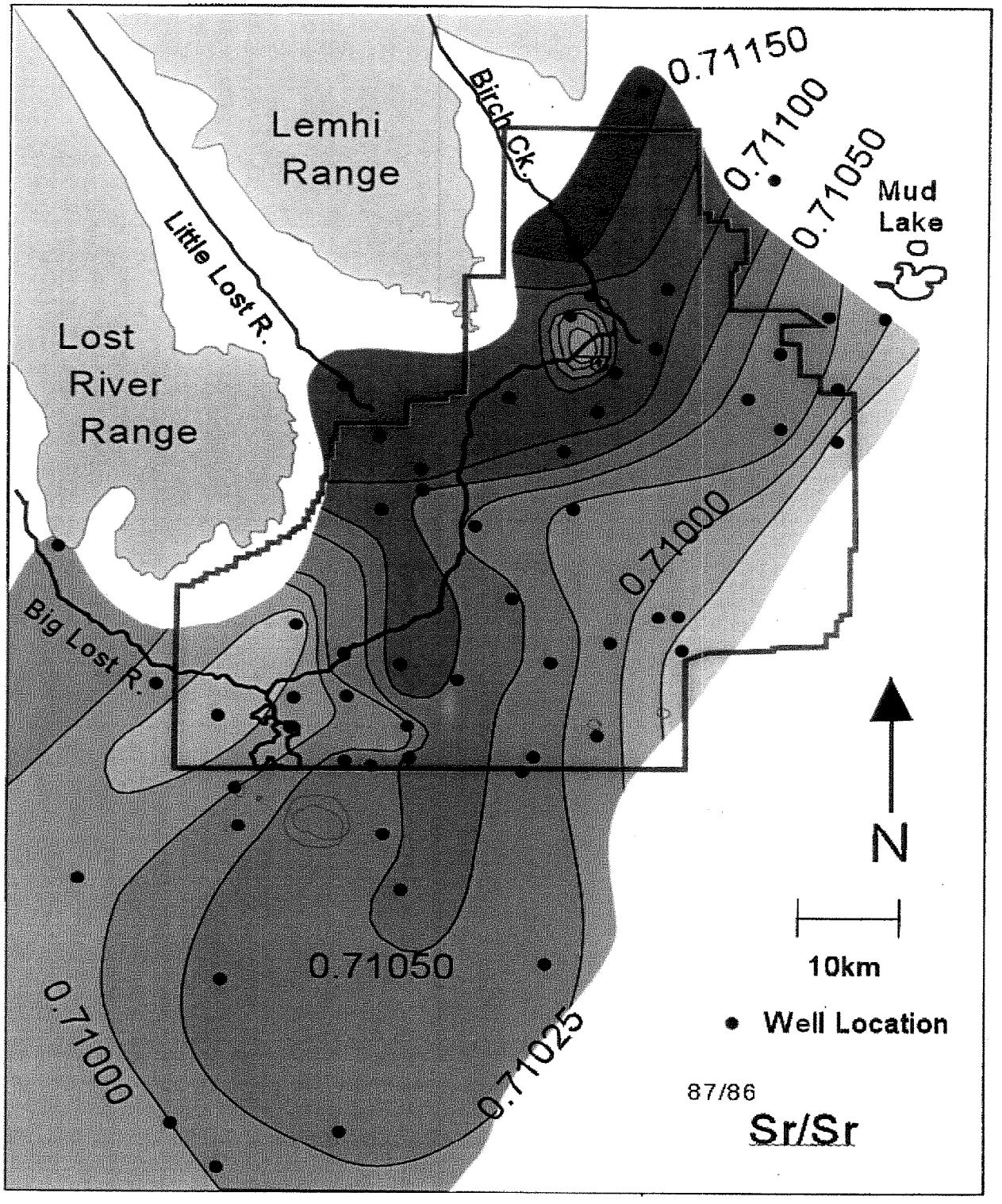
Evidence from chemistry and detailed groundwater elevation data indicate the directions of groundwater flow in the aquifer range from southeasterly to southwesterly within the INEEL area.

This is different than a simple south-westerly flow direction inferred from regional (Eastern Snake River Plain) patterns.

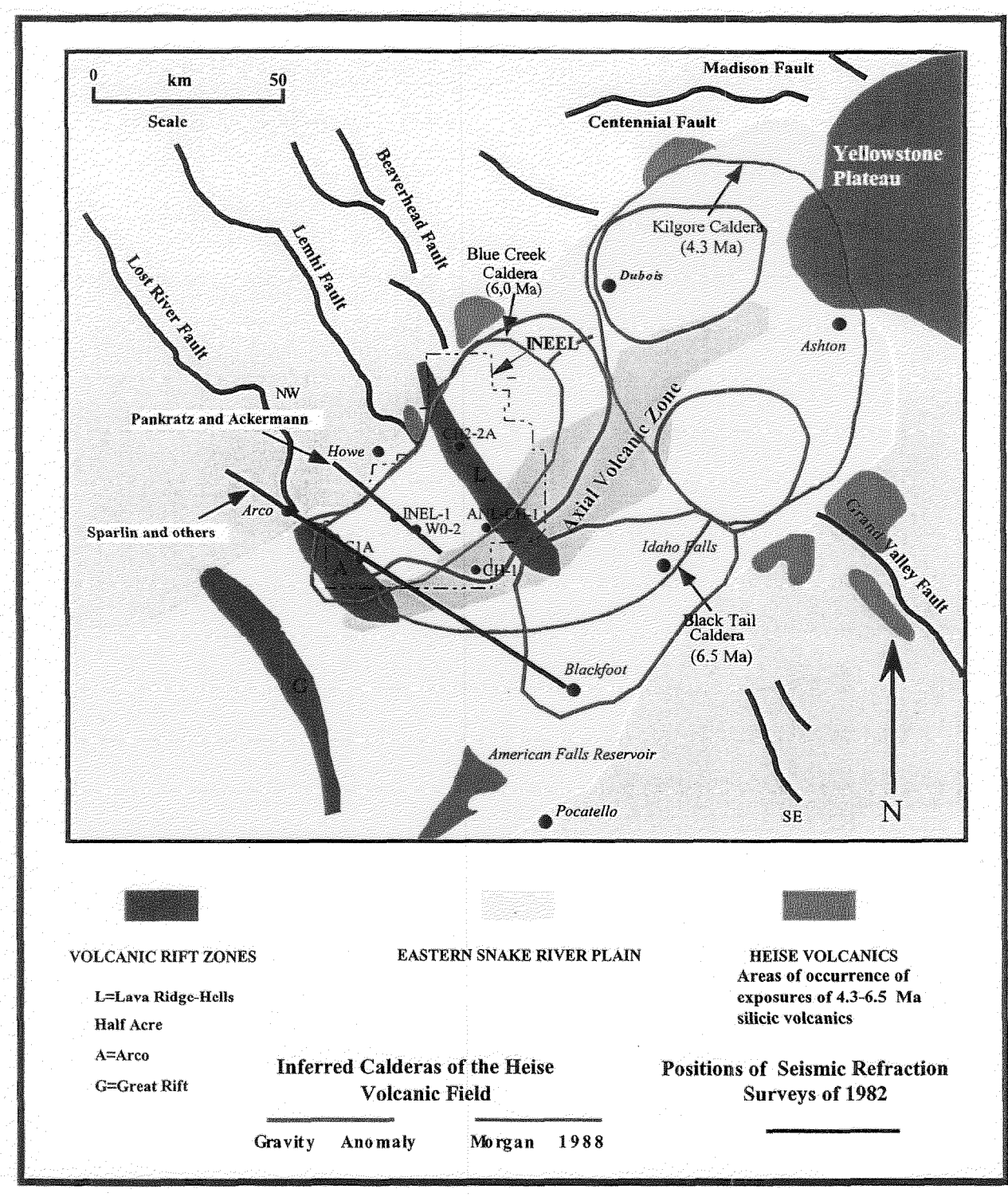
Spring 1999 Head Contours and Handrawn Pathlines



Sr^{87}/Sr^{86} ratio distribution in INEEL scale aquifer water



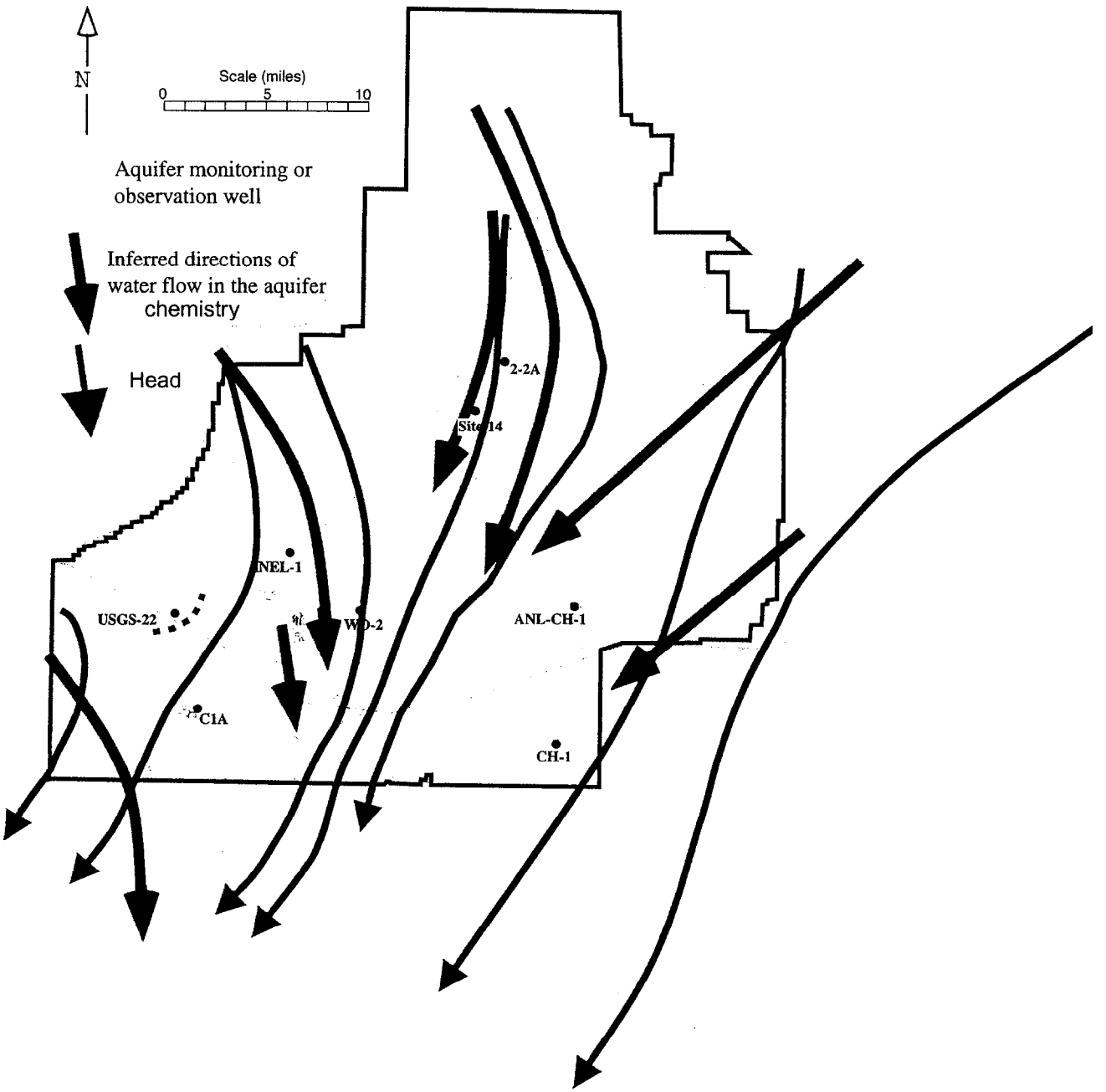
Locations of Volcanic Rift Zones and buried calderas



Rift zones cross general groundwater flow directions and indicate potential for anisotropy

Calderas may be indicators of high heat flux into aquifer system

Inferred groundwater flow directions from chemistry/geology and hydraulic head



Aquifer Property Distributions

- Hydraulic Conductivity
- Specific Storage for Transient Model
- From lithologic distributions
- Effective porosity
- Aquifer thickness
- Model calibration to match head, flow, and chemistry

Temporal Variations

- Initial WAG 10 Model will be steady state
- Groundwater head and flow vary with time across the INEEL
- Seasonal and climatic changes are the primary drivers at the INEEL scale
- Plume development is on time scale of decades
- Temporal variations may average out on the plume time scale, but they can affect a local plume development (more dispersion)
- Some account of temporal variations probably needed - transient model

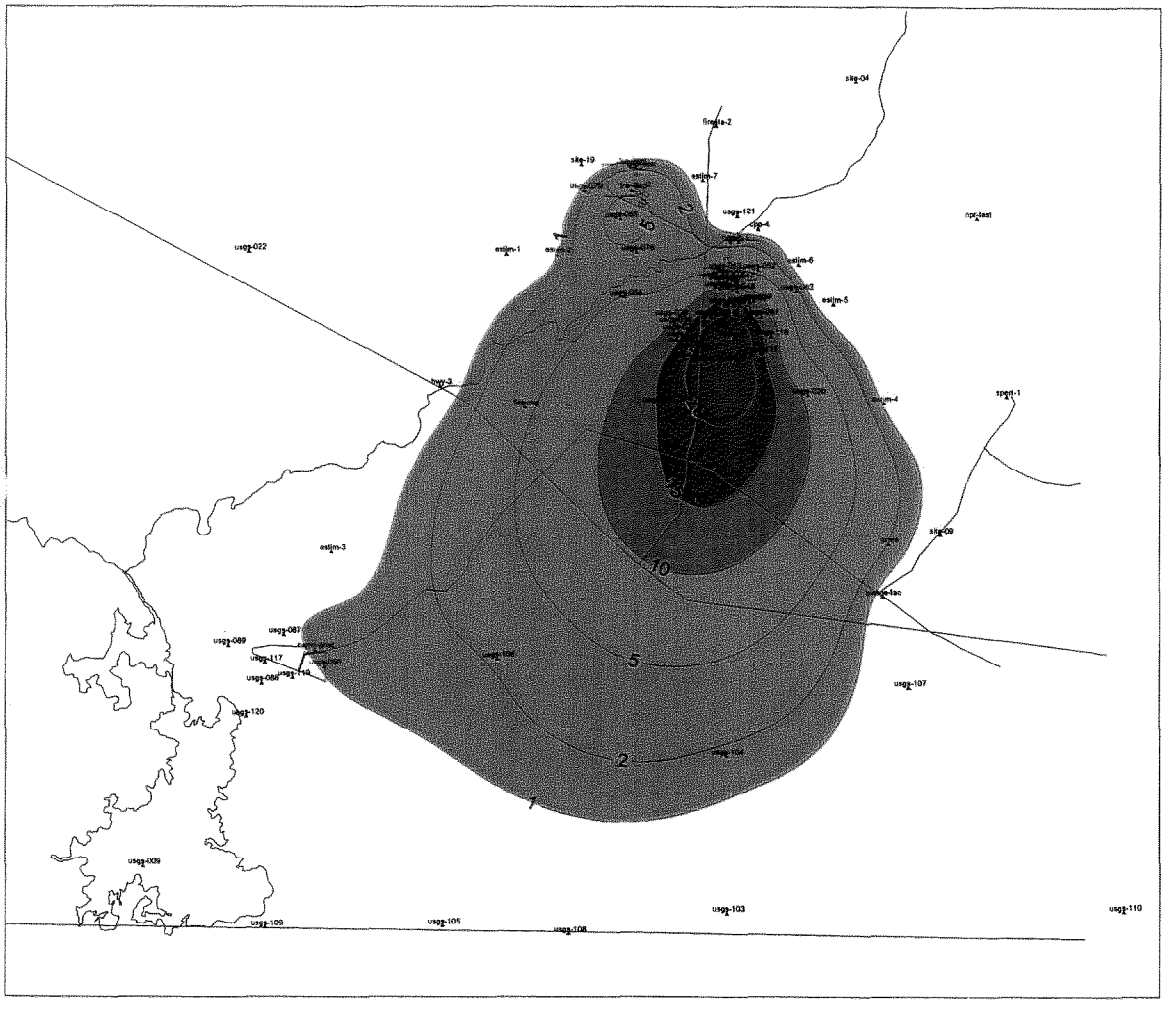
WAG 10 Model Summary

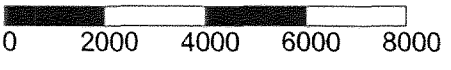
- WAG 10 Conceptual Model Needs to be Updated
- Greater Spatial Resolution and Focus on Facility Specific WAG Needs
- Provide a Consistent INEEL Scale Groundwater Flow and Advective Velocity Field Using Onsite and Offsite Data
- Help Identify Data Gaps and Provide a Tool to Help Resolve Issues
- Evaluate INEEL Scale Cumulative Risk and Integrate Results of other WAG Models.
- Address uncertainty

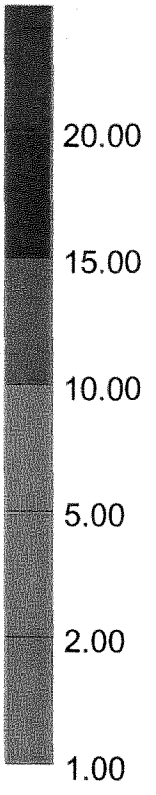
Alternative Tritium Plume Interpretation

- Traditional tritium plume from INTEC and TRA shows a bulge to the RWMC
- This interpretation is not consistent with head gradients
- It was not possible to match this bulge in 1993 EIS modeling
- An 1994 analysis of data and tritium contouring procedures showed that an alternative interpretation was just as likely
- This alternative showed 2 tritium plumes; the main plume oriented essentially directly south and a small, very low level plume at the RWMC

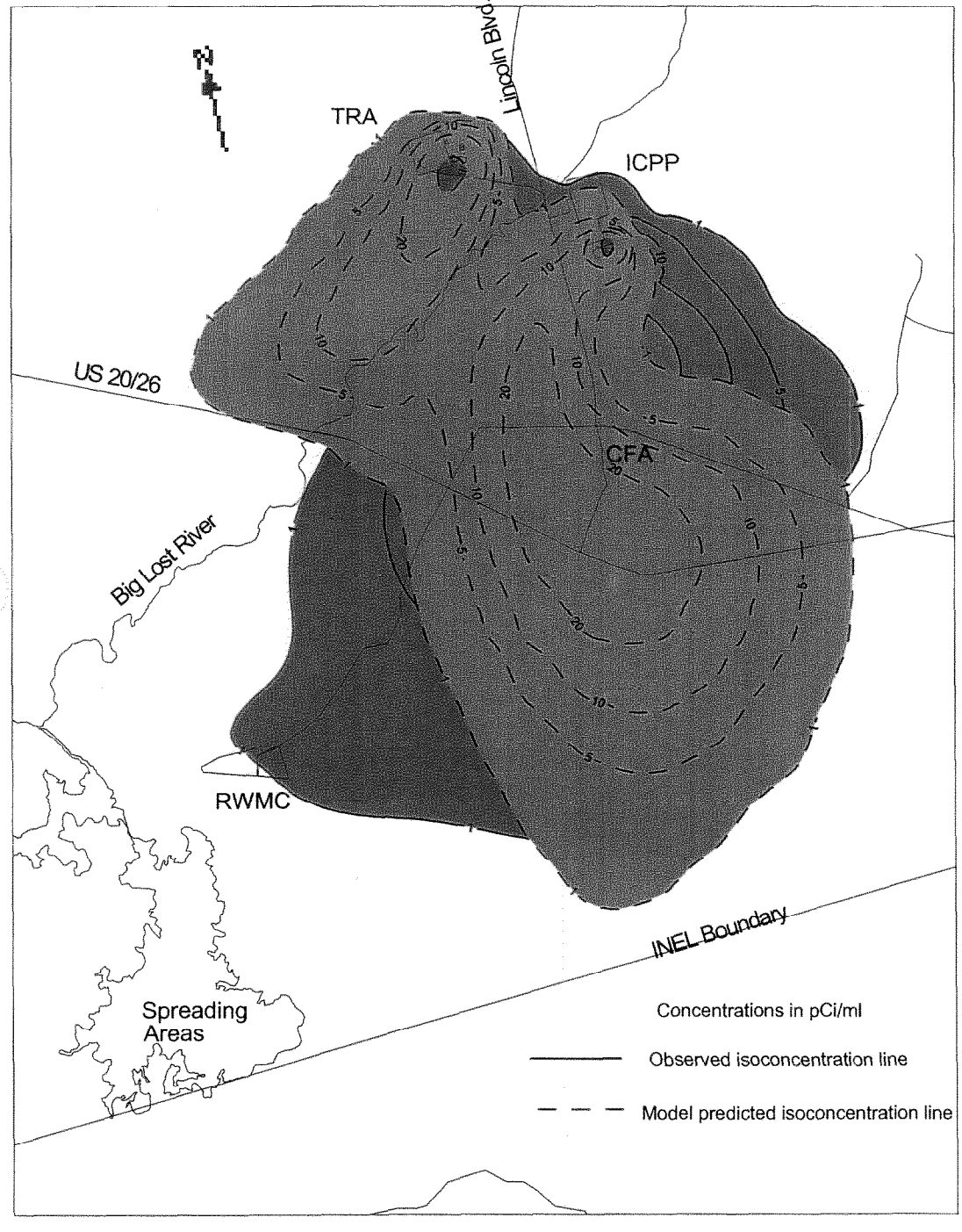
Interpreted Tritium Contours from Observed Concentrations
Spring 1992, pCi/mL



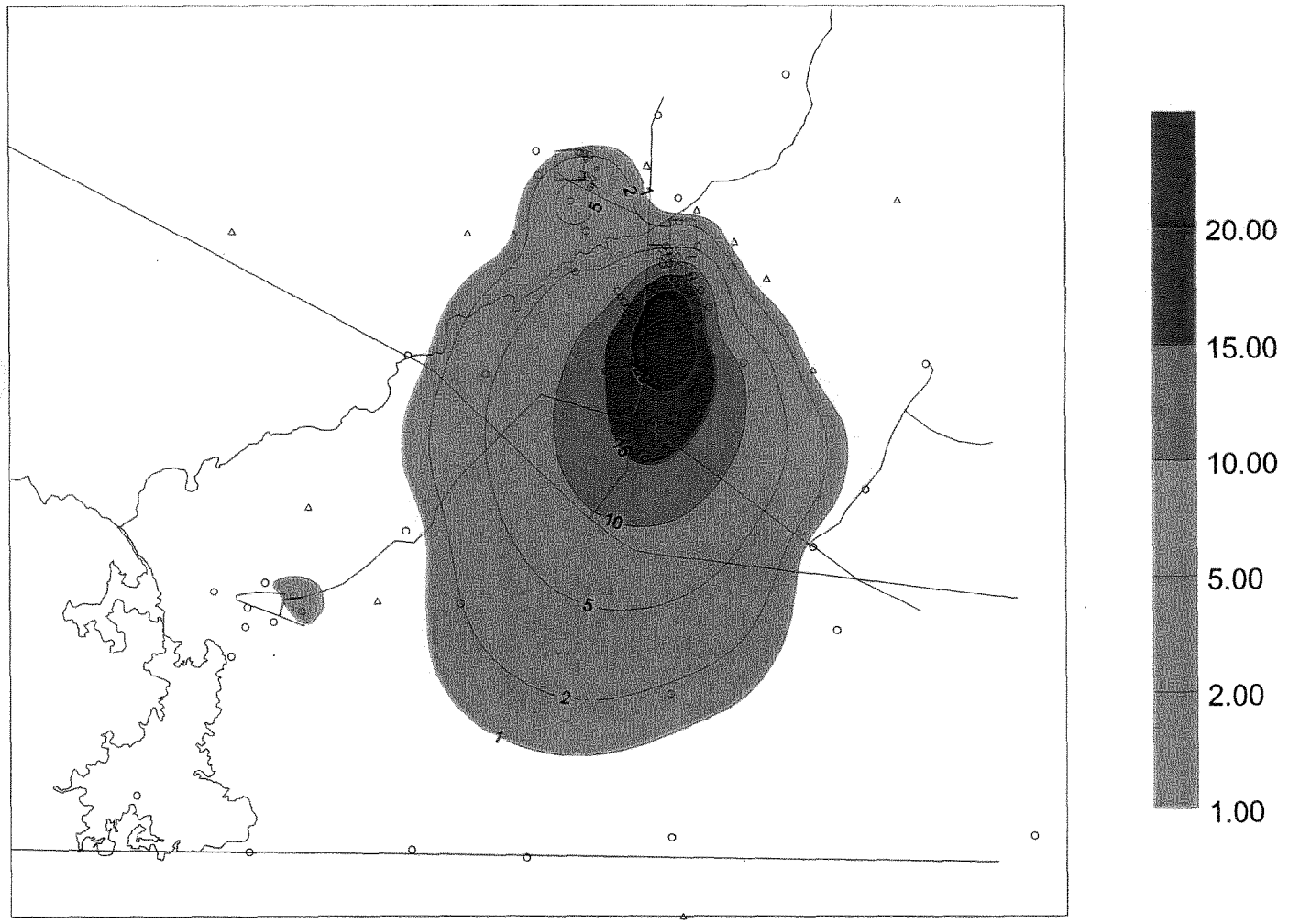




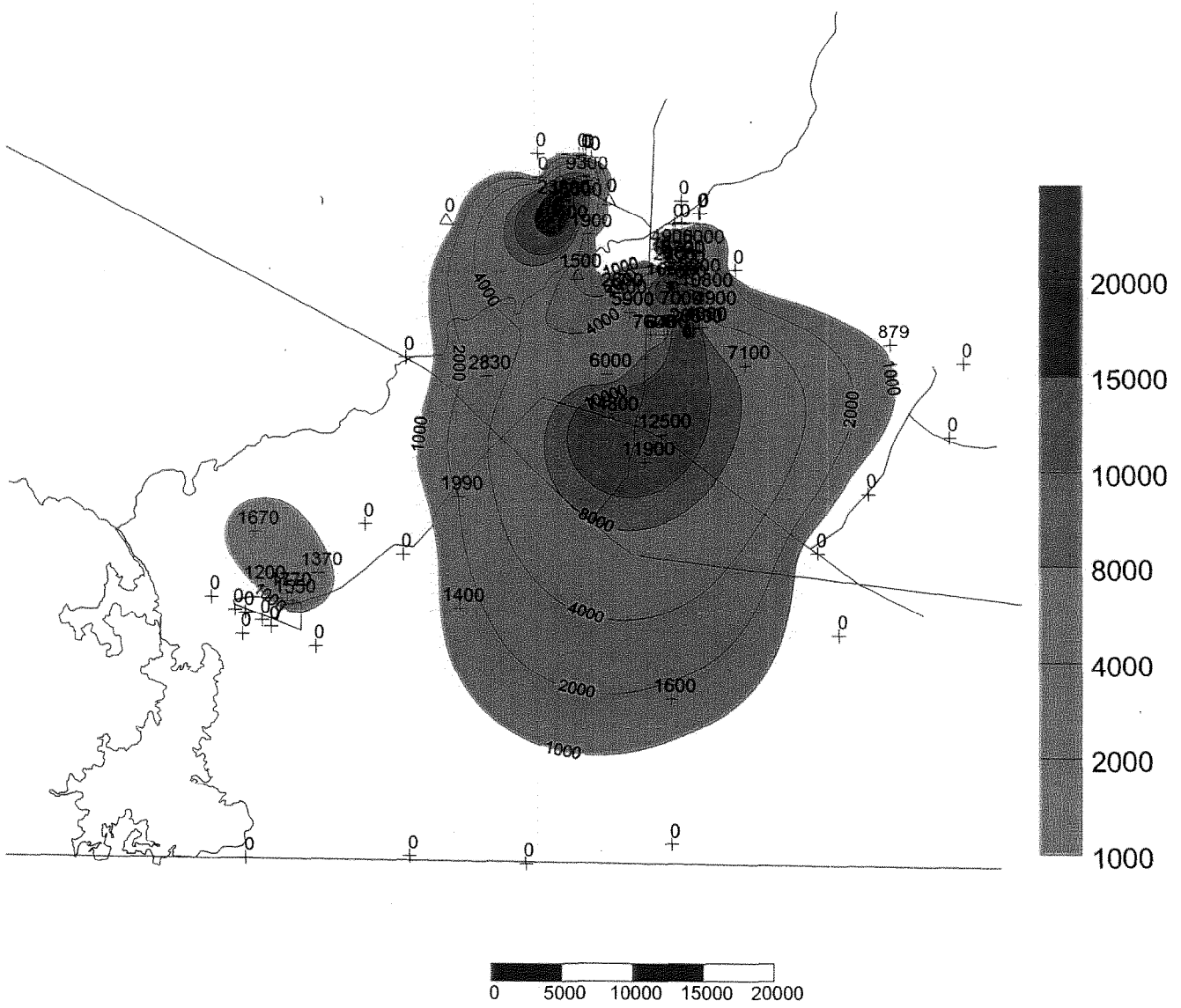
Interpreted Tritium Plume from Observed Concentrations and EIS Modeled H-3 Concentration - 1990



1992 Tritium Contour Map - Alternative Interpretation



Interpreted Tritium Contours from Observed Concentration Spring 1998 (pCi/L)



Alternative Interp. Confirmed by Data

- The alternative tritium interpretation has been confirmed by tritium measurements at recently drilled wells (M11-M17)

- This suggests that there is a small source of tritium at the RWMC that may be moving preferentially northward through the vadose zone most likely via vapor transport and spreading area influences.

Guiding Questions

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[Technical comments by INEEL WAG 10 on USGS guiding questions]

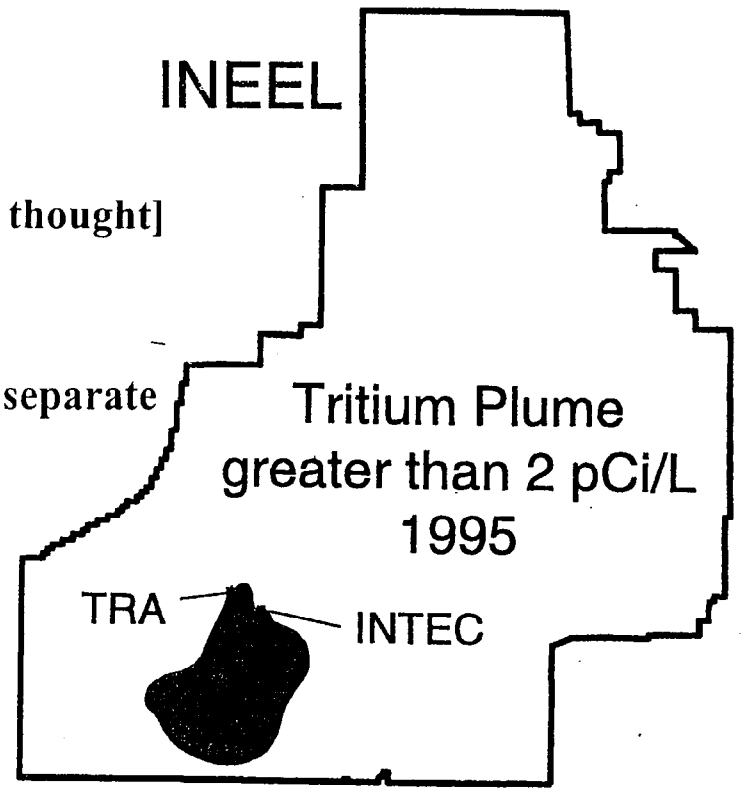
How deep is the plume?

[It may be deeper at some points than previously thought]

Why is the plume so wide?

[It is not as wide as previously thought, there are two separate plumes, one is small and at low concentrations]

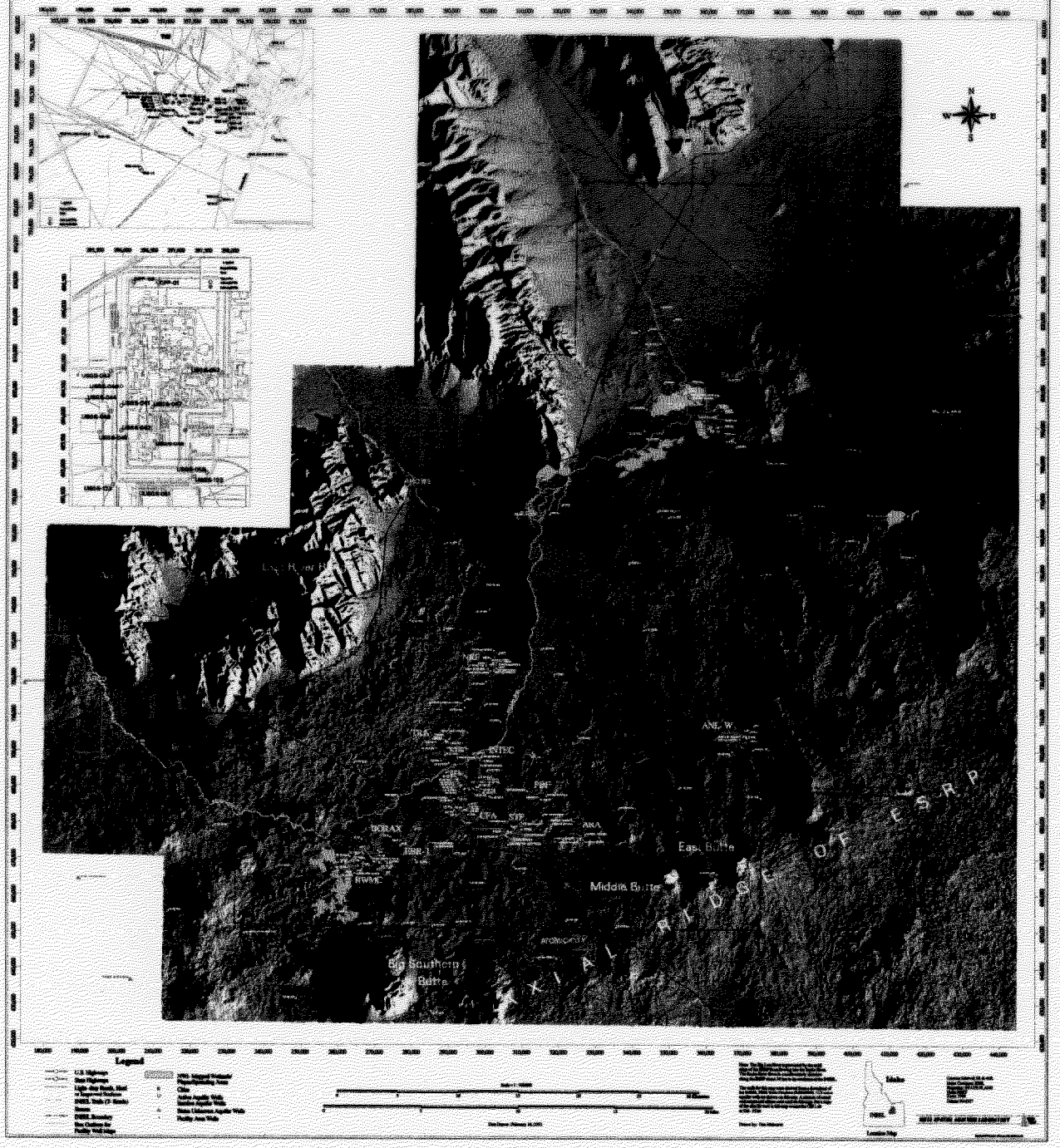
What processes control the contaminant concentration and migration rates?



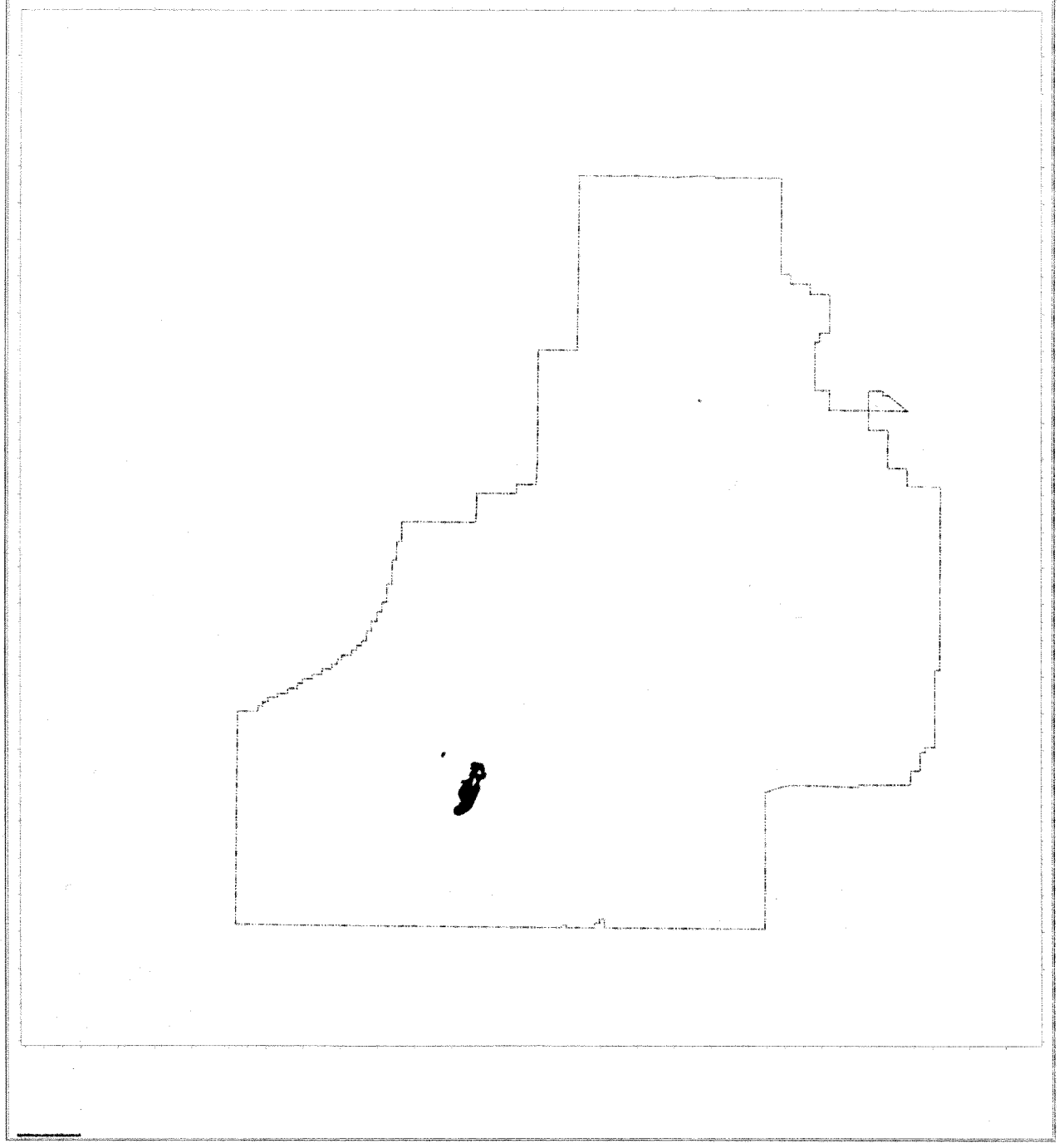
Section E-2. Site-wide Plume Map Overlays.

Idaho National Engineering and Environmental Laboratory

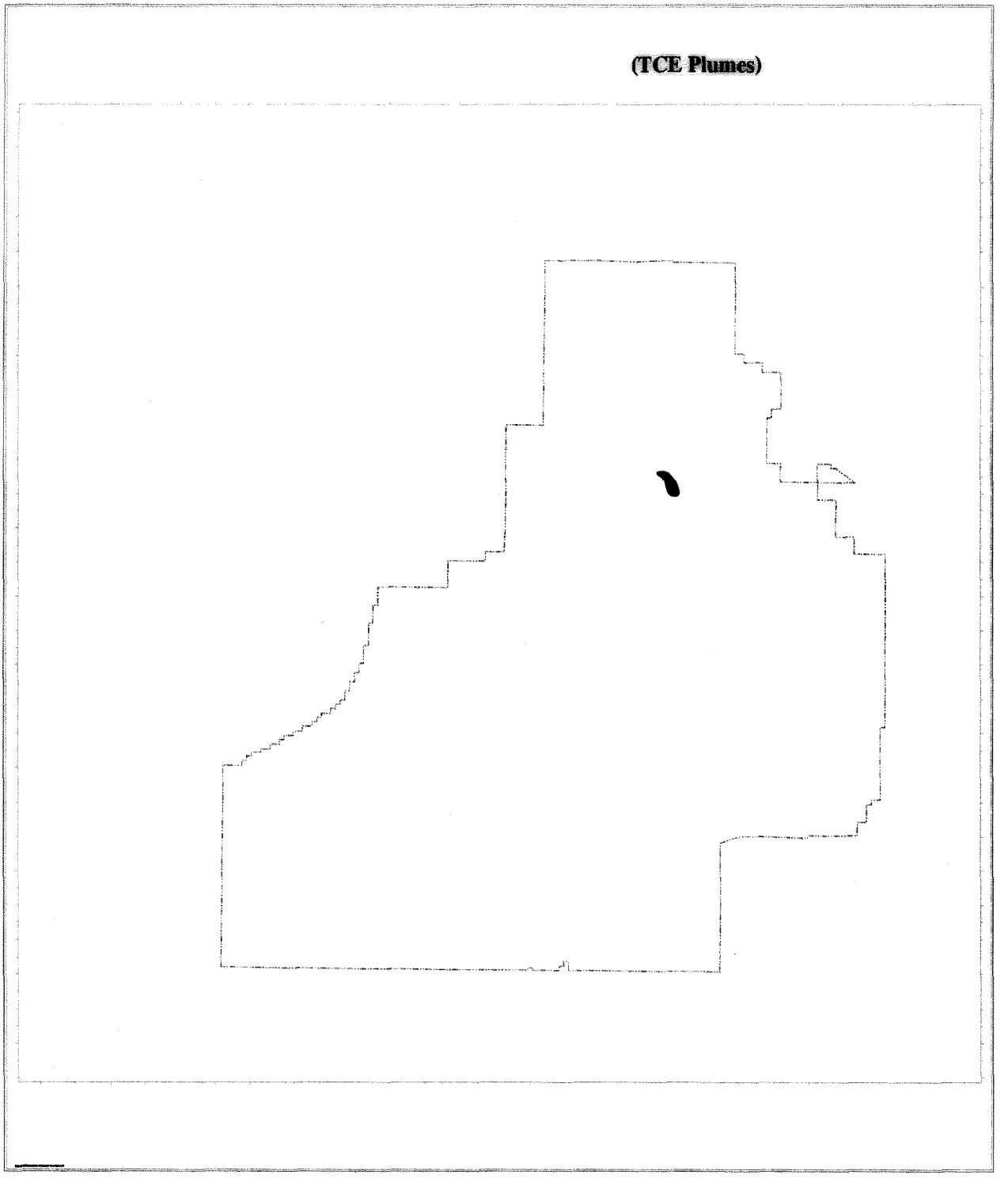
7.5` Shaded Relief and Active Aquifer Wells



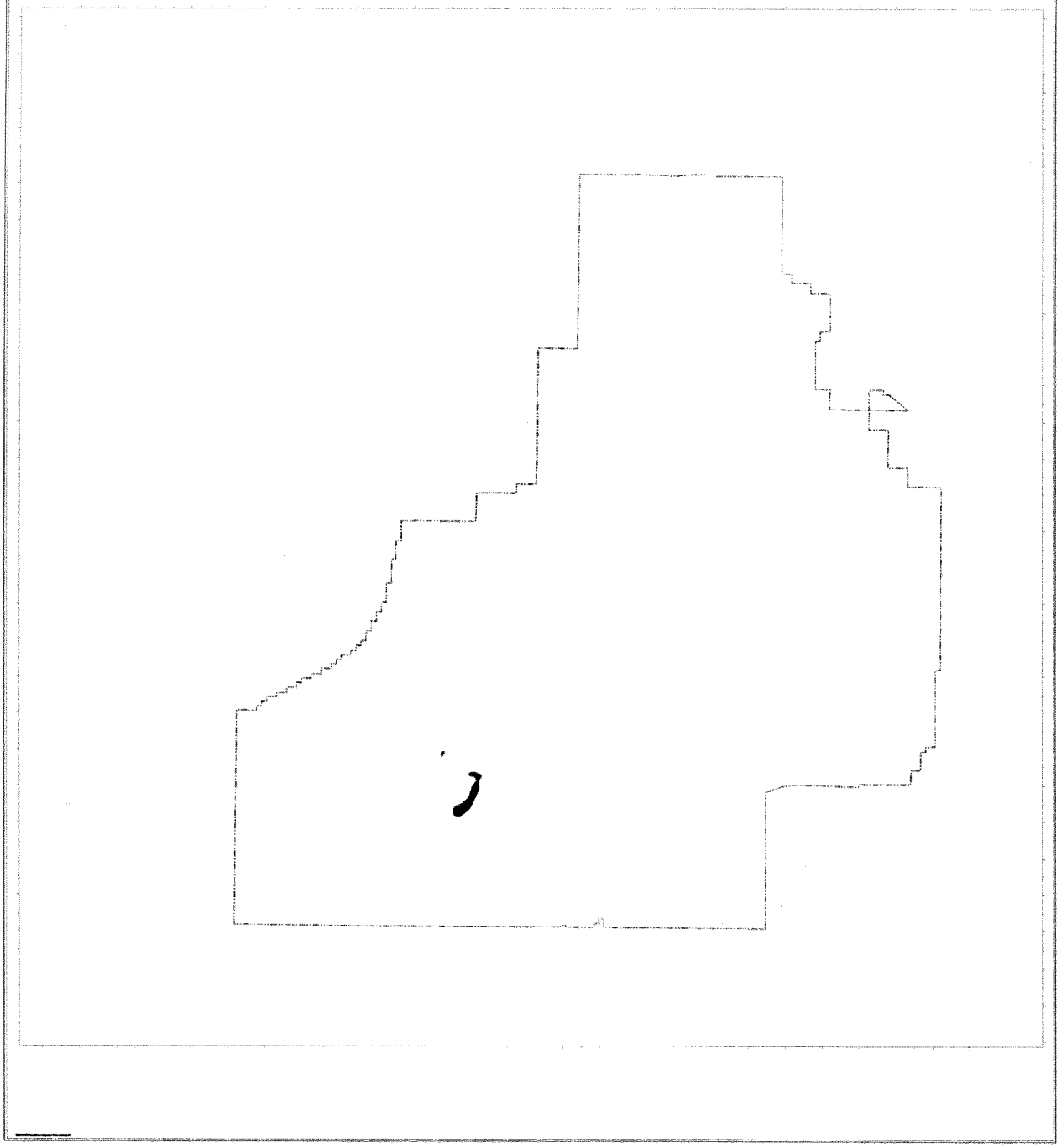
(Radionuclide of Concern Plumes)



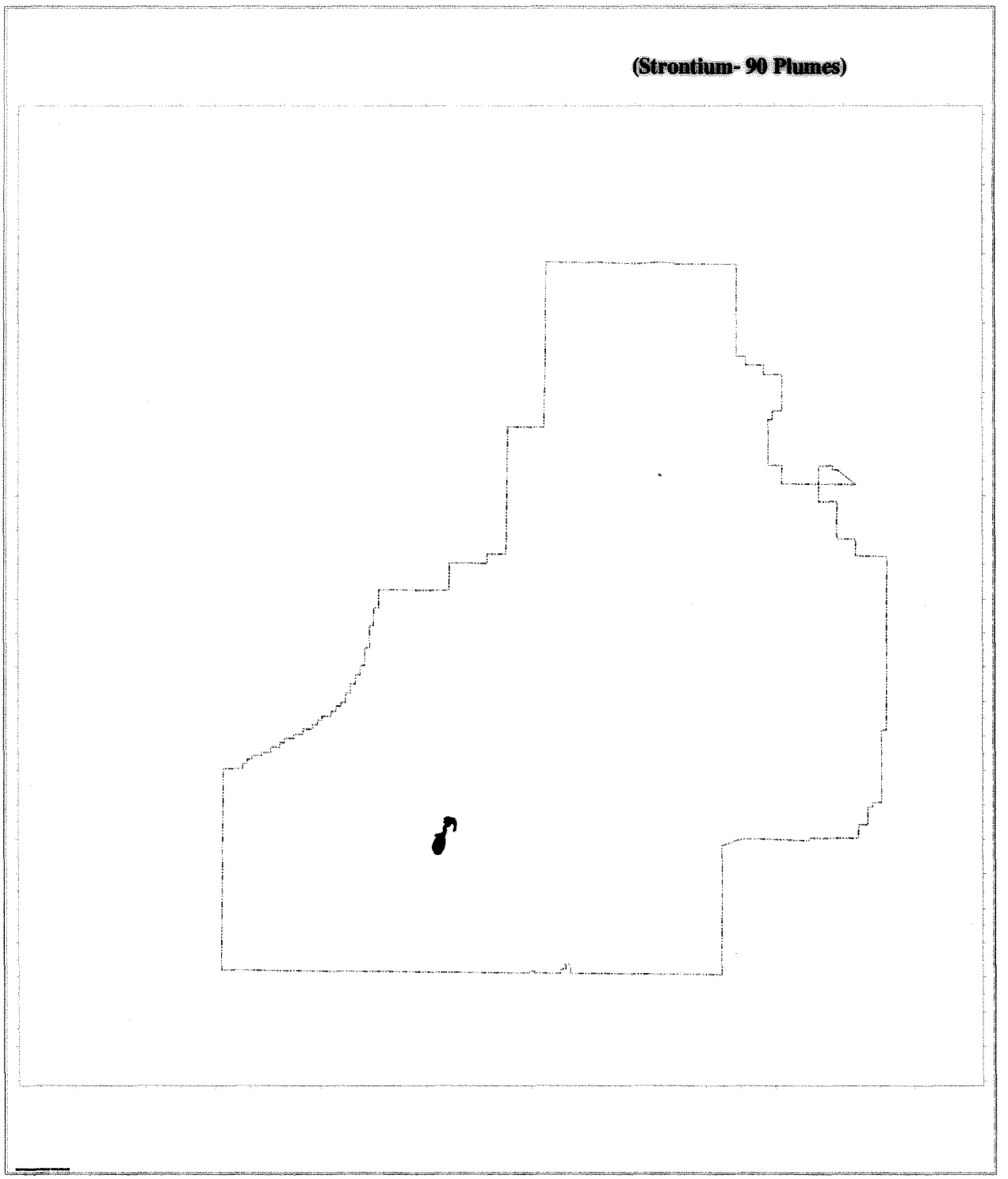
(TCE Plumes)



(Tritum Plumes)



(Strontium- 90 Plumes)



(Chromium Plumes)